

Connect our last parcels of wilderness, like pearls on a necklace, and mountain lions, bobcats, and wolves might once again roam their ancestral ranges

THE MOUNTAIN LION WAS HEALTHY, MALE, AND YOUNG. He was born in the Santa Ana Mountains of southern California, probably in the dry, rugged hills near the seaside town of San Clemente. As a juvenile, he wandered through chaparral, hunting mule deer, jackrabbit, bobcat, and coyote. At 18 months,

the lion—known as M6 to the scientist who tracked his movements—began to roam farther, looking for a home range of his own and a mate.

One night M6 headed north. At midday he rested; when darkness fell, he resumed his trek. About 50 miles into his journey, he left the conifers of the higher peaks in the Cleveland National Forest and dropped down into the sage scrub of Coal Canyon. Its stony creek bed led him into a broad, sandy outwash. Here M6 took stock of his predicament. An eight-lane freeway, Highway 91, the major thoroughfare from Riverside County to Los Angeles, blocked his progress. Hundreds of cars every hour streamed past. M6 sniffed out a derelict underpass.

It was noisy and uninviting, but he made it through, leaving the highway behind and entering the relative calm of Chino Hills State Park. For 187 days M6 stayed put, patrolling 12,000 acres of low, grassy hills. Then he started to move again. Chino Hills, apparently, wasn't big enough.

Twenty-two times over the next 19 months, M6 made the journey back and forth under Highway 91. He became a street-smart lion, but the passage was always perilous. To reach the canyon, M6 had to work his way across two shrubless golf courses, which offered little in the way of protective cover, and past a stable. Before he could get to the freeway, he had to cross a double set of busy railroad tracks. This was, by any sentient being's measure, difficult terrain. Arc lights glared; traffic roared.

Despite the obstacles, M6 stitched together an hourglass-

shaped home territory of some 168 square miles between the Chino Hills and the Santa Ana Mountains. Coal Canyon connected the lobes of the hourglass. For M6 it had become a corridor of life and death. The lion could easily have been hit by a car (at least six mountain lions were killed by cars in southern California last year), kicked by a horse, or flattened by Amtrak. But M6 had little choice:

The Chino Hills contained only enough prey to support one or two female lions. If M6 wanted to pass on his genes, he had to survive the Coal Canyon choke point.

And life for this lion was about to get even harder. A developer had plans for 652 acres just south of the freeway: 1,500 houses, plus all the usual gas stations and fast-food outlets that attend the birth of a neighborhood. Building and paving would sever the already tenuous connection to Coal Canyon. According to Paul Beier, the scientist who collared M6 and tracked him for months, "the loss of this corridor would guarantee the extinction of the mountain lion from Chino Hills and endanger the entire population of lions in the Santa Anas."



WILDING AMERICA

WILDLIFE CORRIDORS HAVE A WONDERFUL, UTILITARIAN SIMPLICITY, especially in a crowded place like southern California, where the prospect of creating large new preserves is relatively limited. Here many biologists believe it makes sense to connect smaller, established parks— islands of biological diversity— with wildlife corridors. These may be blocks of ranch land, ribbons of land alongside streams, or highway underpasses. Strung together like green beads on a necklace, each piece of land could become part of a larger whole. Animals like M6 would be able to move freely, get enough food, woo a mate, and reproduce. "We can tweak the margins of our parks and wilderness areas, extend them a little here or there," says Beier.

"But to make them viable over the long term, we have to think about how we're going to link them."

Linkages in southern California tend to be modest in size, but some conservationists, thinking more ambitiously, envision linkages as an integral part of a far grander scheme: the re-wilding of the entire continent. Across North America, large parklands could be connected either through the acquisition of additional land parcels, which would form corridors, or by retrofitting roadways with underpasses that let animals move freely between reserves. Populations of creatures that have been driven from their native habitats—wolves, for example, or black-footed ferrets—would be restored. The time for such conservation megaprojects, writes the evolutionary biologist Edward O. Wilson in *The Future of Life*, "is now, because the windows of opportunity are closing fast."

THE CONTEMPLATION OF WILDLIFE CORRIDORS GREW OUT OF THE *Theory of Island Biogeography*, written by Wilson and the ecologist Robert MacArthur in 1967. The theory states, in simplest terms, that bigger islands closer to mainlands have more species than islands that are smaller and more isolated. Several decades ago biologists realized that the same theory could be applied to protected parks that had become isolated as developments and roads tightened around them. Fragmenting forces—whether a golf course, a clear-cut, or a four-lane highway—effectively make islands out of nature reserves. Even relatively large parcels of land can be doomed to islandhood, according to one often-cited study. Bryce Canyon National Park, Lassen Volcanic National Park, and Zion National Park have each lost about 40 percent of their larger mammal species since they were founded. Humans either killed them off directly or reduced their habitats.

Population biology theory suggests that without migratory routes, animals in small parks, like animals on small islands, may be subject to the same inbreeding pressures as zoo populations. Corridors may counter this effect by allowing a dwindling population in one area to be supplemented by individuals from another. They allow adolescents to disperse and genes to flow among populations. Animals can migrate to establish new home ranges, as M6 did, and follow their prey from higher to lower elevations as the seasons change. They can move in response to short-term environmental change such as fire or drought and long-term environmental change such as rising temperatures. "Protecting linkages will ensure these species don't blink out in the short term," says Kristeen Penrod, executive director of the South Coast Wildlands Project. "In the long term, they will let these species evolve."

ONE SUNNY WEEKEND, BEIER, PENROD, AND ABOUT 200 BIOLOGISTS, land managers, and town planners met at the San Diego Zoo to plot the future of California's natural heritage. Poring over maps and animal censuses, they identified 232 missing linkages

deemed critical for preserving the state's biodiversity. Out of that total, 60 potential linkages lay in the south coastal region of southern California. This richness of local opportunity surprised no one. Thanks to its Mediterranean climate and its mountainous terrain, the area between Los Angeles and San Diego contains 2,500 plant species that live nowhere else in the world. A lot of plants at the bottom of the food chain mean a lot of animal diversity higher up. The area is, in conservationists' jargon, a biological hot spot.

Unfortunately, a great deal of that biodiversity is about to disappear. Southern California has more threatened and endangered species than any other region in the continental United States. By some estimates, 200 plant species and 200 animal species—from bighorn sheep to foxes and butterflies—are imperiled.

The problem is too many people. Supermarkets, condos, and offices have already wiped out about 90 percent of the region's wetlands. This constitutes a significant environmental blow because wetlands filter pollution, absorb storm runoff, and provide habitat for thousands of plant and animal species.

Furthermore, most of San Diego's 2.8 million residents live within several miles of the Pacific Ocean, where nearly all the coastal sage scrub has already been plowed under to build houses and shopping centers. Coastal sage scrub alone contains more than 35 plant species, two insects, seven reptiles, four birds, and seven mammals that are listed as endangered or are candidates to be listed.

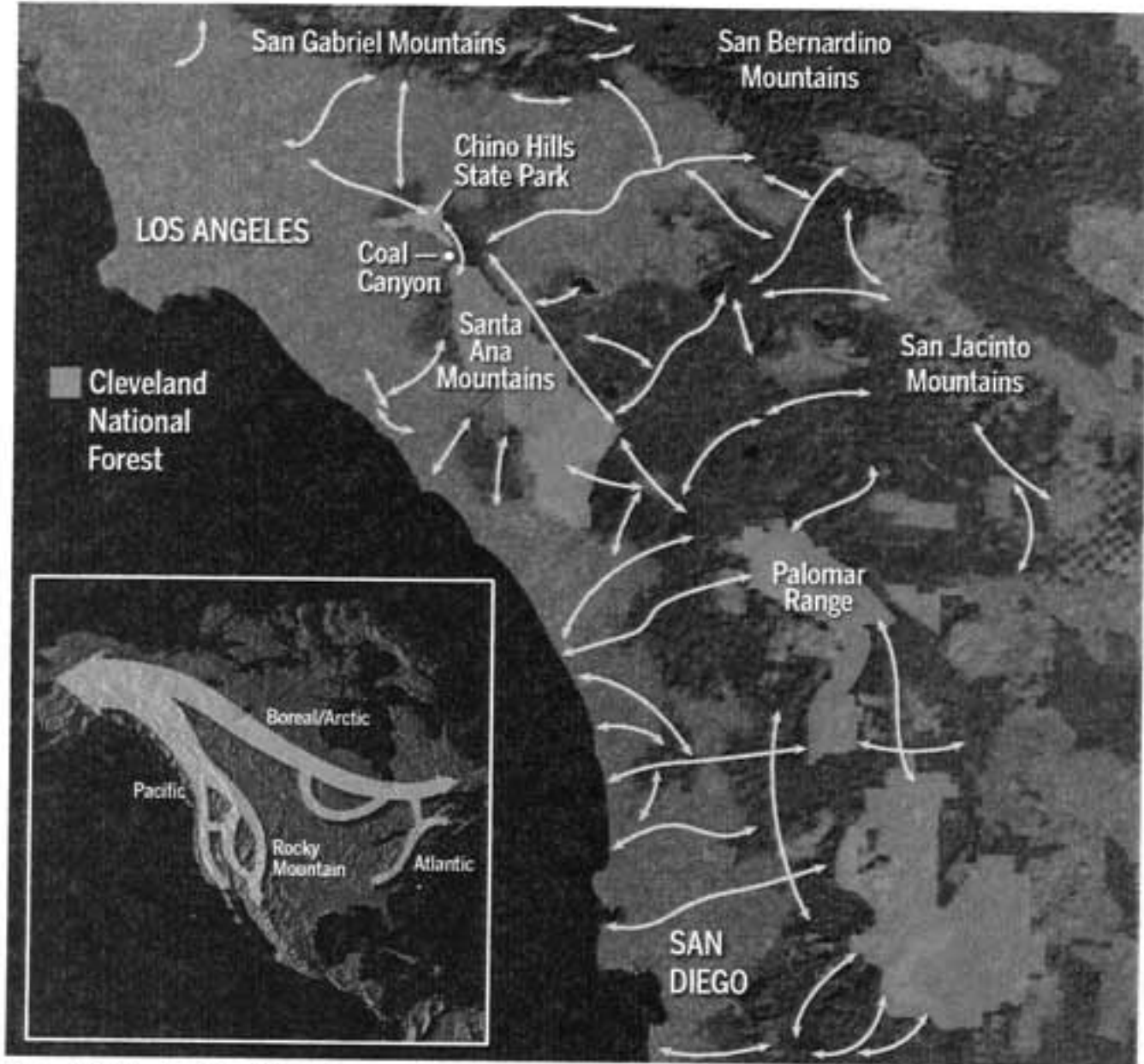
To document which creatures are hanging on in the remaining green pockets—and how they eat, breed, migrate, and die—biologists are doing some odd things.

In the chaparral, they're dripping the anal scent of bobcats onto rocks to lure felines toward camera traps. They must prove how many bobcats are present and whether they're successfully breeding to make a case for preserving bobcat habitat. In the mountains, biologists are setting foothold snares to capture lions, which they'll fit with radio collars. They're dusting animal paths with gypsum powder so they can quantify the footprints of anything that walks by.

Mountain lions get a lot of attention from conservation biologists. They need large home ranges and large populations of animals, like deer, to eat. Youngsters need plenty of room to disperse and mate. If lions, which have stalked these mountains for millennia and shaped the evolution of numerous interconnected species, don't get more space soon, says Beier, they will simply disappear. Forever.

The extinction of mountain lions might please homeowners with pet Pomeranians and calicos that wander near the Chino Hills, but should the species disappear locally, a cascade of effects would ripple through the food chain. Deer would proliferate, overbrowsing forests and shrubs that harbor smaller animals. Free of their feline nemesis, populations of middle-size predators, such as skunks, raccoons, gray foxes, and opossums, would boom, decimating populations of smaller prey animals. In addition to mice and voles, nesting birds

Southern California has more threatened and endangered species than any other region in the continental United States



Conservationists hope to create hundreds of wildlife corridors (indicated by arrows) that they deem critical to the survival of dozens of native California species. The linkages above are located in the densely populated area between Los Angeles and San Diego. Inset: A more ambitious plan would create several "megalinkages" connecting North America's fragmented wilderness and thus allow for the free movement of wide-ranging carnivores such as wolves, bears, and mountain cats.



Biologists use radio collars and hidden cameras to track the movements of carnivores through areas thought to be critical wildlife corridors. Coyotes (A), mountain lions (B), and foxes (C) regularly cross under freeways as they make their way from the Santa Ana Mountains to the Chino Hills.

would take a hit, including the endangered California Gnatcatcher. Birds keep invertebrate populations in check, and they also move around a lot of seeds, which grow into plants that feed other birds, butterflies, and other small animals.

About a century ago, mountain lions could be found in nearly every continental state. Now the only hope of seeing them again lies in the work of conservationists who design networks to restore the wild cats' movement. In the Southeast, for example, connected parklands could enable a young male panther in the Florida Everglades to stake out a home territory near his relatives in Georgia's Appalachians.

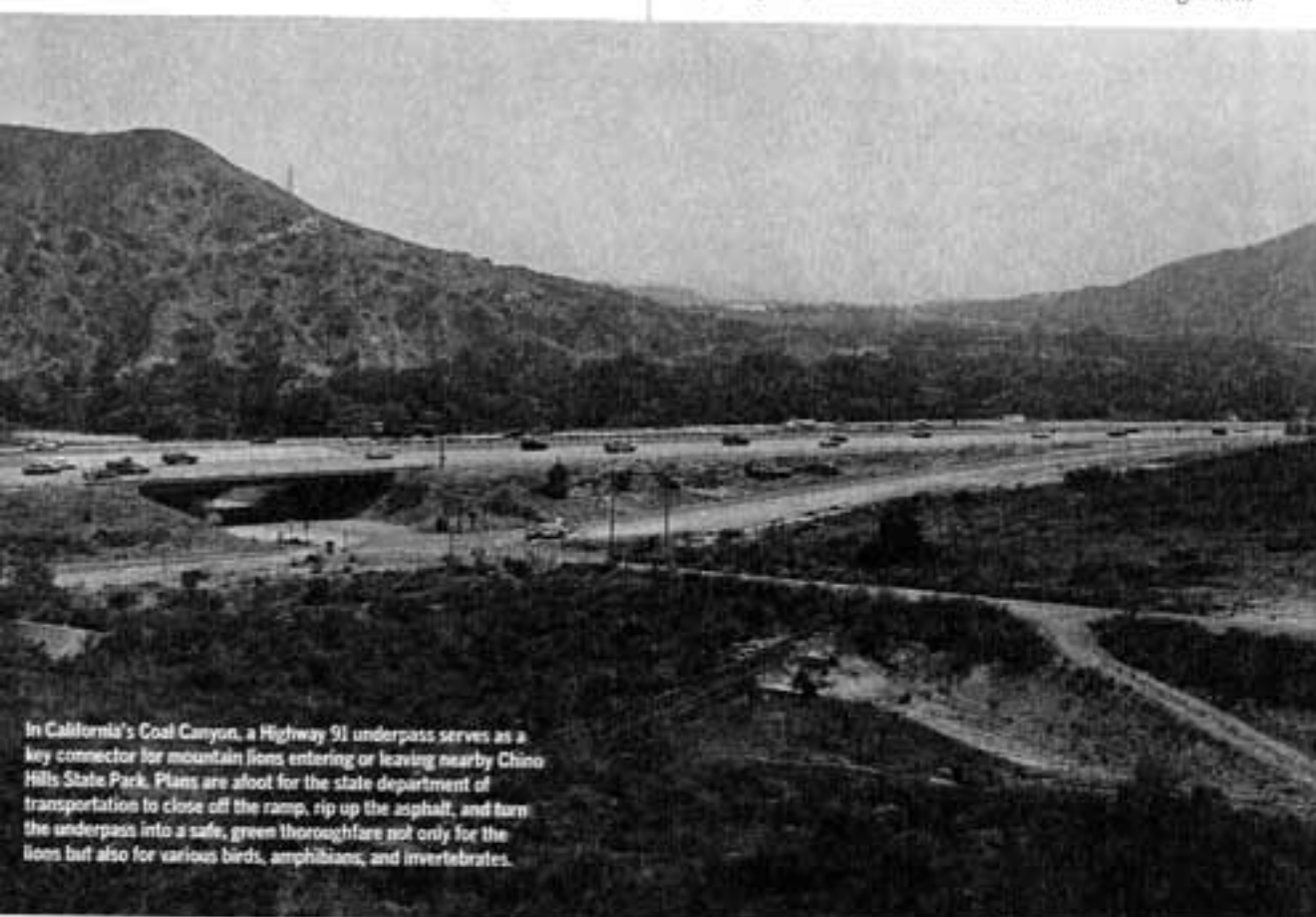
The idea of restoring the movement of large carnivores across America, of establishing wilderness corridors that stretch across the continent, seemed far-fetched when an environmental group called the Wildlands Project proposed it more than 10 years ago. But the vision has worked its way into the mainstream. The group's goals, writes Paul Ehrlich, professor of population studies at Stanford University's Center for Conservation Biology, "have now been embraced broadly as the only realistic strategy for ending the extinction crisis."

In the West, biologists have already drawn a blueprint for connecting the upland habitats of southern New Mexico, southern Arizona, and northern Mexico. The plan calls for the recovery of all large carnivores native to the region, for the

restoration of watersheds, forests, and natural fire regimes, the establishment of movement corridors, and the control of non-native species. Similar goals are being set for a 2,000-mile swath of forest that stretches from the Yukon all the way to Yellowstone National Park, and for the southern Rockies, from Wyoming to the Sierra Madre in Mexico. In the East, conservationists envision an Appalachian corridor of more or less continuous forest from western Pennsylvania into eastern Kentucky.

"It's an incredible dream," says Michael Soulé, emeritus professor of environmental studies at the University of California at Santa Cruz and a director at the Wildlands Project. He imagines jaguars, ocelots, and jaguarundis prowling over their historical range in Texas, southern New Mexico, and Arizona, as well as wolves running "through most of the mountains. There's plenty of habitat and food for these animals." Grizzlies could range in a nearly continuous chain from the Sonoran mountains of Mexico to the Yukon.

The Wildlands Project doesn't call for dismantling roads, pipelines, or shopping centers. Instead, members hope to expand, connect, and restore wilderness areas by consolidating new developments and adapting buildings and other structures already in place. In the northern Rockies, for example, the group would like to limit construction of shopping centers along a major highway that threatens to sever the flow of large carni-



In California's Coal Canyon, a Highway 91 underpass serves as a key connector for mountain lions entering or leaving nearby Chino Hills State Park. Plans are afoot for the state department of transportation to close off the ramp, rip up the asphalt, and turn the underpass into a safe, green thoroughfare not only for the lions but also for various birds, amphibians, and invertebrates.

vores between Canada and the United States. The plan calls for retrofitting the highway with underpasses for wild animals.

LINKAGES IN SOUTHERN CALIFORNIA DON'T HAVE THE GRANDEUR OF A Yukon-to-Yellowstone wildlife corridor. But some local conservationists believe southern California can be a model for planning across the country. "Other National Park Service people look here for lessons," says Ray Sauvajot of the Santa Monica Mountains National Recreation Area. "All our parks are being encroached upon. Even the Yosemite Valley floor is becoming fragmented." Southern California is unique, both for its intense population pressure and for how much biodiversity is at stake. "But if corridors can work here," Sauvajot says, "then they'll work anywhere."

Although Sauvajot is talking about political success, some scientists question the very assumptions of wildlife corridors. They ask if corridors might usher disease or exotic species from one reserve to another. So far, there's no evidence that this has occurred. But it's difficult to design a rigorous study of corridor utility. For comparison's sake, researchers would have to build a corridor and also remove a corridor, then track animal movement and reproductive success for years. Biologists have a great deal of empirical evidence that animals use corridors, but they don't know yet if the right animals are using them at the right time, or if some predators might use them as avenues to kill prey that they wouldn't normally encounter.

"In most cases, there is no direct evidence that corridors are used for movement or that movement is important to the persistence of a population," says biologist Dan Simberloff of the University of Tennessee at Knoxville.

"There has been no real study of their cost-effectiveness," Heier believes money spent on corridors could be better spent buying larger parcels of land. In southern California, the debate seems irrelevant. There aren't many large parcels left to buy.

Beier says little is known about how well corridors function. In 1998 he and biologist Reed Noss of Oregon State University reviewed 32 studies of wildlife corridors and found that fewer than half provided persuasive data. Still, they concluded, "well-designed studies suggest that corridors are valuable conservation tools," Beier invokes the precautionary principle: In the face of serious threat, a lack of certainty shouldn't prevent taking action to prevent or minimize that threat. "It may be better to build a corridor and find out what happens than to lose the land to development. We don't want to find out what will happen if we lose these corridors."

Taking a contrarian view, Simberloff argues for "management procedures over buying corridors. We could restore habitat, move animals to other reserves, hire more wardens, and build fences to keep lions off highways."

While biologists battle, private conservancies and California's Department of Fish and Game are busy buying land for corridors. They either buy outright from willing sellers, or

they broker trades, wherein an owner who holds undeveloped land deemed critical to a corridor exchanges it for state-owned land of equal value that isn't. Land may also become part of a corridor through conservation easement: The Nature Conservancy, for example, buys land, then resells parcels with restricted development rights.

Pat and Jeanine Stammers bought five sage-dotted acres smack in the middle of the Tenaja Corridor, a three-mile-long swath that lies just west of Riverside County's teeming suburban developments. The corridor connects the 8,300-acre Santa Rosa Ecological Reserve with a 160,000-acre section of the Cleveland National Forest. In theory, a lion could travel south from Chino Hills State Park through the national forest and all the way to the Santa Rosa reserve, about 70 miles away.

While some of their neighbors have easements, the Stammers have an understanding with the Nature Conservancy that limits building on the land, stipulates that any fences must be friendly to wildlife, and stops them from clearing native vegetation. "We didn't think we were giving up anything," says Jeanine Stammers. "We moved out here to be with nature." Every morning she watches a pack of coyotes trot past her house.

Judy Kollar bought land in the corridor because "I knew this would be a model for how people could live in semi-wilderness areas and make as little impact as possible. I'd consider the plan a failure if I didn't see coyotes up here." A fifth-generation southern Californian, Kollar takes natural heritage personally. "I'm a connoisseur of the local landscape," she says. "I have an aesthetic reaction to its being plowed under."

There are others like Kollar. In Orange County, Claire Schlotterbeck rallied support for mountain lions and other species that needed to pass through the bottleneck of Coal Canyon. After a two-year effort, her advocacy group, Hills for Everyone, persuaded the state to put up \$14.7 million to help buy out the real estate developer who had planned on building condos south of Highway 91 and to purchase an additional 32 acres of land just to the north.

"The department of transportation is restoring the underpass," says Geary Hund, a state parks department wildlife ecologist who worked with Schlotterbeck. "We'll get rid of the lights and put up some sound barriers. We'll pull up the pavement under the freeway and set up some fencing to steer animals off the highway and down under." Native vegetation will be planted on the compacted slopes; Coal Creek's concrete waterway will be ripped up and half its natural flow restored. Instead of cement, he says, imagine willows and mule fat shrubs. Then imagine birdsong in the air, and butterflies.

And imagine M6 still prowling around. When the lion study was over, Beier removed the radio collar. He likes to imagine that M6 is going strong. "He's the only male in that area," Beier says. "He's pretty tough. I bet he found a female." He pauses to think, then adds, "I sure hope so." ☐

Restoring the movement of large carnivores across America once seemed far-fetched, but the idea has worked its way into the mainstream